United States Patent [19]

Okuno

[11] **3,892,391**

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[54] **COOLING APPARATUS FOR STEEL INGOTS OR BLOOMS USING HIGH-SPEED JET STREAMS**

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[52] **U.S. Cl.** ..... **266/2 A;** 266/5 R; 266/5 L

[51] **Int. Cl.** **C21d 1/00**

[58] **Field of Search** ..... 266/5 H, 2 A, 2 L, 5 R; 432/121, 123, 126, 133; 65/114, 115, 118, 119, 120

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[57] **ABSTRACT**

The present invention relates to a cooling apparatus for substances such as steel ingots or blooms which utilizes high-speed jet streams. The apparatus is provided with a casing comprising two or more zones. At least one of said zones is a high-speed jet zone in which a fluid having a low temperature is jetted onto the substances being cooled. A convection current cooling zone or another high-speed jet zone is connected to the first high-speed jet zone. A conveyor operates to successively feed the substances being treated into the casing, through the zones and to successively extract the thus treated substances from the casing. While in the high-speed jet zone or zones, the substances being treated are cooled by a heat transfer occuring at the surfaces of the said substances, said heat transfer being created by jetting a low temperature fluid onto the said surfaces.

The invention also relates to a cooling apparatus as above described which acts in conjunction with a separate cooling tank to cool substances such as steel ingots or blooms. The substances after passing through the casing are transferred to the cooling tank by a carriage and a conveying roller device. In the cooling tank the substances are rapidly cooled to approximately normal temperature through the action of flowing streams of water or other cold liquids.

14 Claims, 9 Drawing Figures

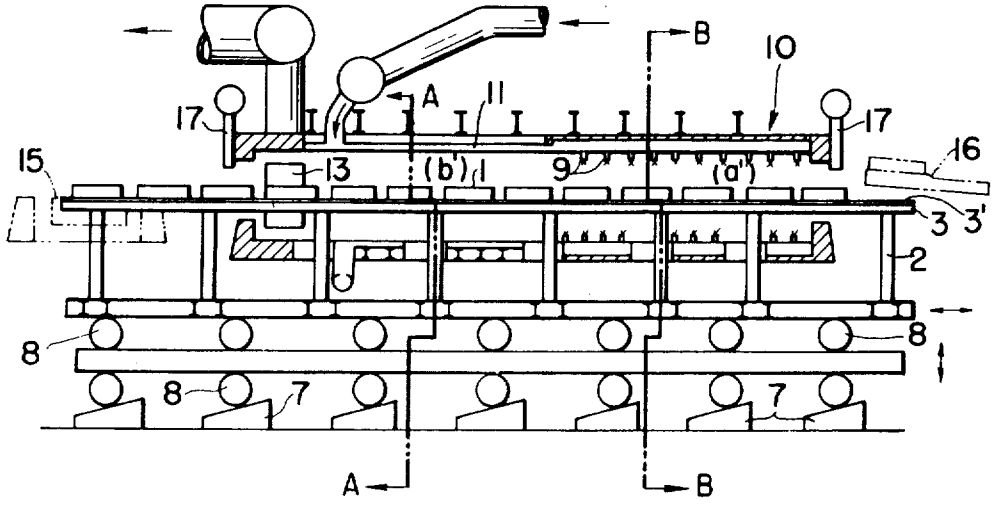


FIG. 1

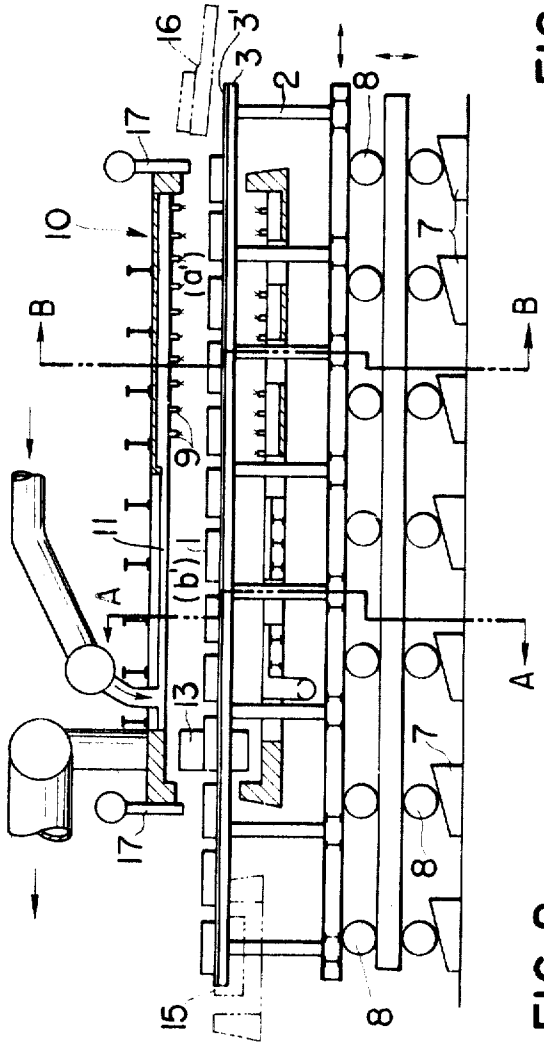


FIG. 3

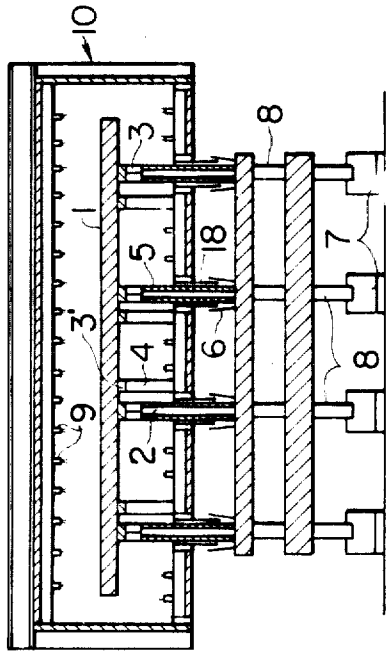
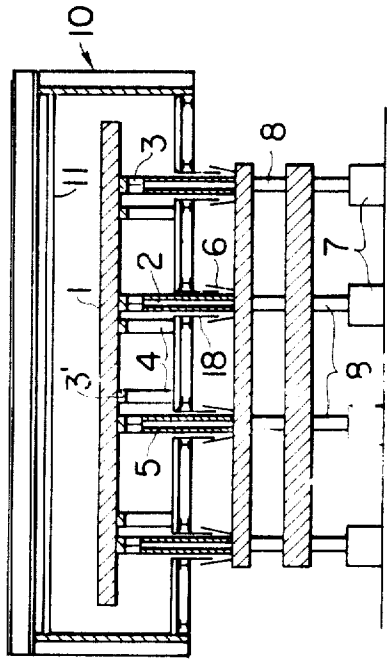


FIG. 2



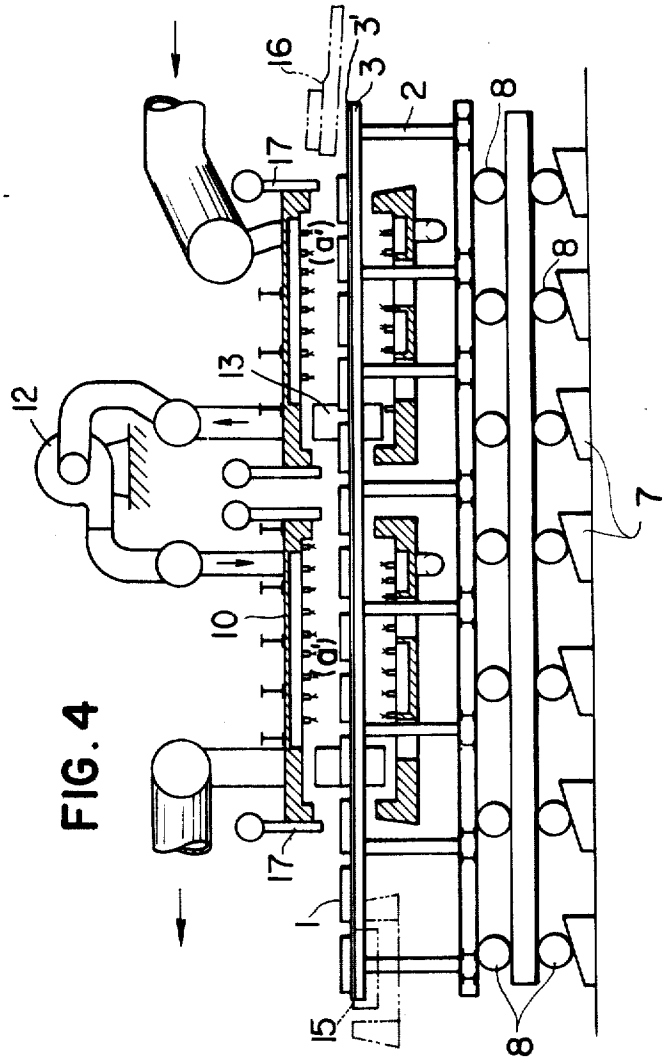


FIG. 4

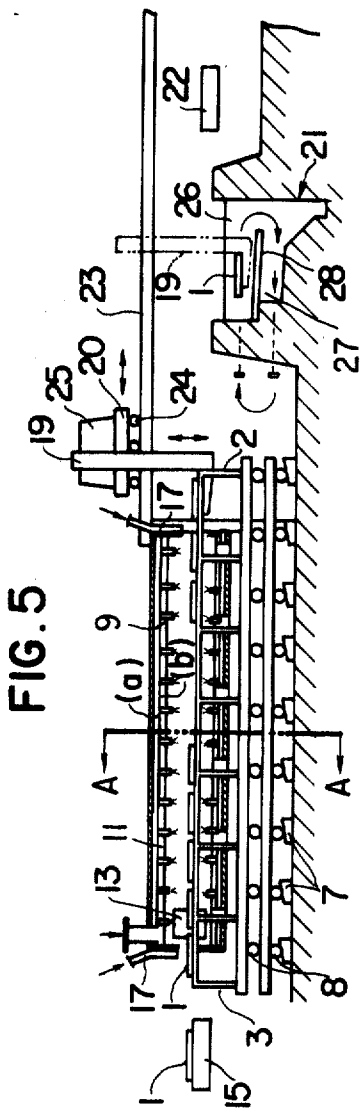


FIG. 5

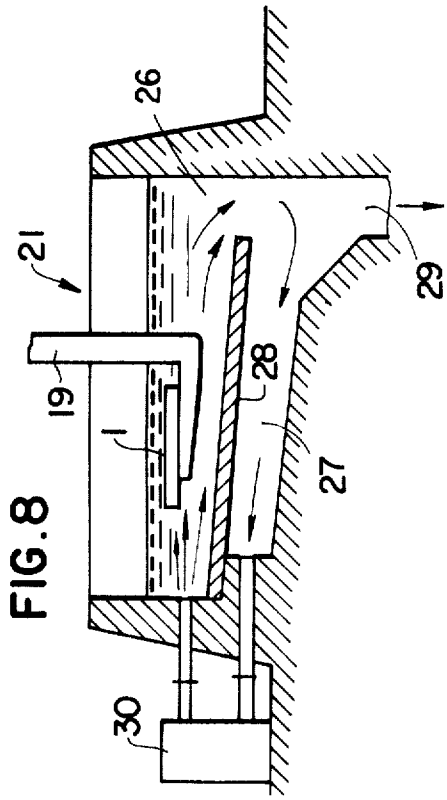


FIG. 8

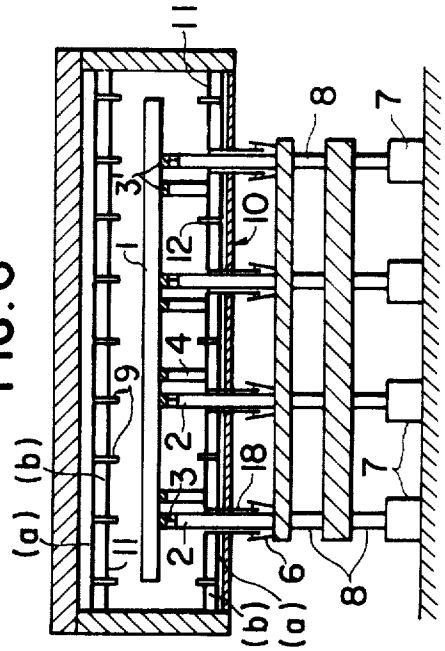
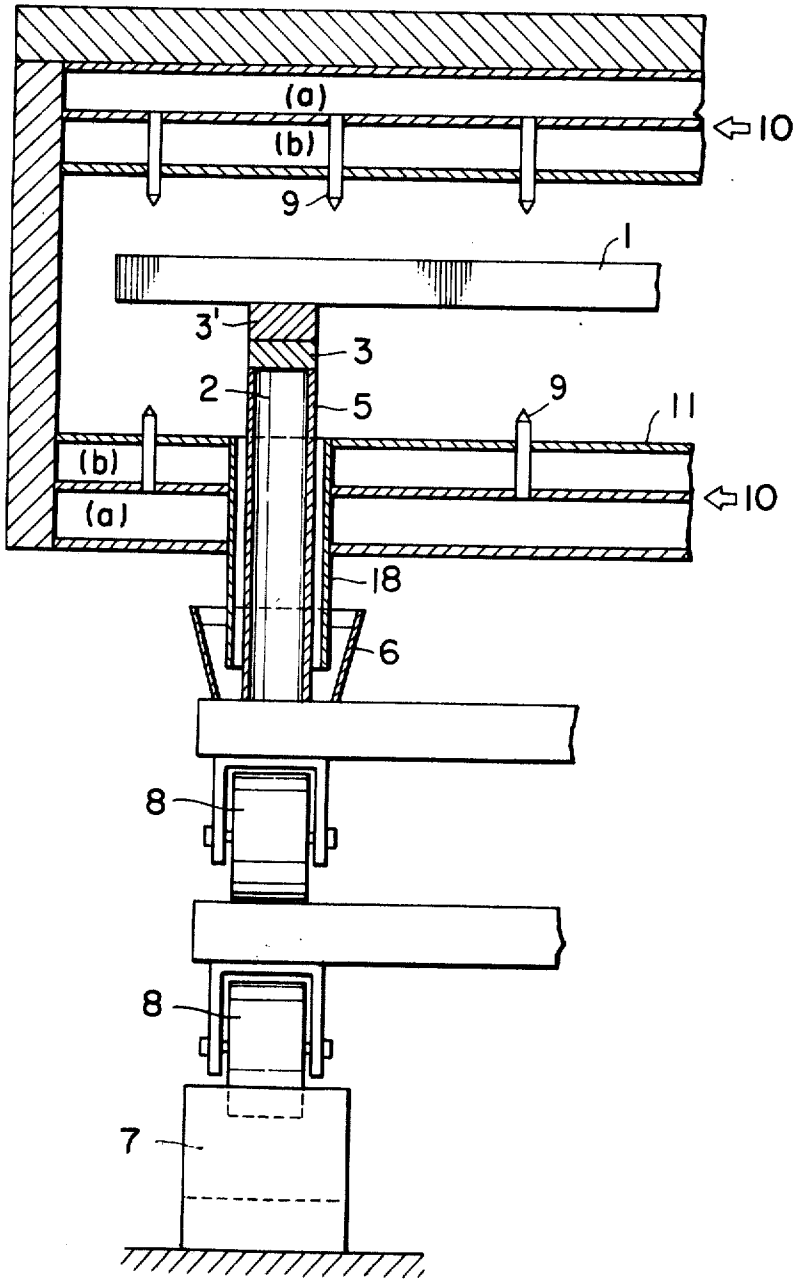


FIG. 6

FIG. 7



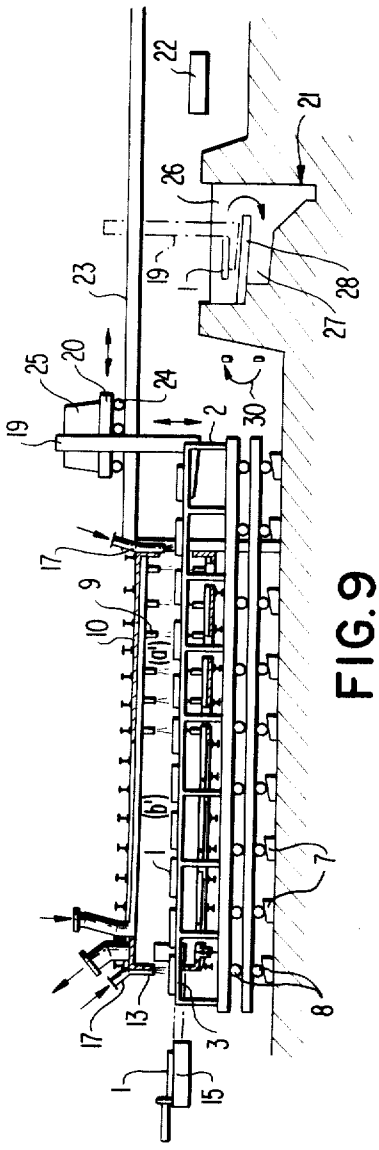


FIG.9

COOLING APPARATUS FOR STEEL INGOTS OR BLOOMS USING HIGH-SPEED JET STREAMS

BACKGROUND OF THE INVENTION

The subject matter of the present invention resides in a cooling apparatus in which a heat transfer is conducted between the substances to be treated, such as steel ingots or blooms, around which a large number of nozzles are arranged, and high-speed jet streams which gush out from the said nozzles, by utilizing the high coefficient of heat transfer on the surface of the said substances which results from the said jet streams.

The average coefficient of heat transfer (hm) on the surface of a plate against which the jet streams gushing out from a large number of arranged nozzles are flown vertically, is as follows:

$$Num = hmx/\lambda = 0.286\ uax^{0.625}/\nu$$

hm is defined with respect to the difference between the temperature of air before being flown into the nozzles and the temperature of the plate.

ua is a flowing speed in the center of the jet streams at the position of the plate.

x is a distance between the respective nozzles.

λ is a thermal conductivity, and γ is a coefficient of kinematic viscosity.

The subject matter of the present invention also resides in a cooling apparatus which operates to continuously cool the said substances such as steel ingots or blooms.

DESCRIPTION OF THE PRIOR ART

In a cogging mill equipped in an iron works, an ingot having a temperature of **1,300**°C which has been carried out from a soaking pit is rolled under pressure into slabs, blooms, etc. by means of a blooming mill, and then in the next step, the thus treated substances are fed into a rolling mill where the same are rolled to prepare a final product. In this case, the slabs or blooms which have been prepared from the ingot in the cogging mill are sometimes stored in the said mill, for the purpose of repairing any defective parts thereof or by virtue of production control, say restriction of output, whereupon it is necessary to cool the said substances nearly to normal temperature since these substances have a very high temperature of about **800**° – 900°C immediately after the treatment in the said blooming mill.

For the purpose of cooling the bloomed slabs or blooms, various conventional means have hitherto been taken. In the conventional case, the said means comprise pouring water onto the slabs or blooms or putting the same into a water tank, after the temperature of the said substances has been lowered by spontaneous cooling. In these means, therefore, a very broad space is required for the said spontaneous cooling, and thus these means involve various defects such as high construction expenses for factory, low operation capacity of apparatus, etc.

SUMMARY OF THE INVENTION

The present invention is intended to improve the uneconomical operation of the conventional means wherein a large amount of heat energy contained in an exhaust gas is thrown away.

It is a primary object of the present invention to transfer the heat energy contained in the substances to be treated to a low temperature liquid so as to lower the temperature of the said substances with simultaneous efficient utilization of the heat energy which has been transfered from the said substances. This is accomplished by jetting the said low temperature fluid from nozzles onto the said substances, under high speed, and by utilizing the high coefficient of heat transfer occurring on the surface of the said substances.

Further, the present invention also relates to a cooling apparatus to cool the substances for a short period of time and to compactly integrate the whole apparatus for the said cooling treatment, for the purpose of eliminating the various defects of the prior art techniques as explained above, by utilizing the high coefficient of heat transfer conducted on the surface of the substance to be treated by the combination use of high-speed jet streams of a low temperature gas having a flowing speed of about **50** – 100 m/s or more than **100** m/s and a high-speed water flow in a water tank, etc. More precisely, the present invention provides a cooling apparatus consisting of a combination of a high-speed jet chamber which contains an interior conveyer therein and which operates to cool the substances to be treated having a temperature of about **800**° – 900°C by means of the high-speed jet streams, and a cooling tank which operates to further cool the substances which have already been cooled to about **400**° – 500°C in the said jet chamber, said further cooling being nearly to normal temperature by means of the high-speed water flow therein.

DETAILED DESCRIPTION OF THE INVENTION

Now, some preferred embodiments of the present invention will be explained with reference to the drawings attached hereto.

FIG. **1** is a partly cut-away side elevation of a cooling apparatus embodying the present invention.

FIG. **2** is a sectional view taken on the line A—A of FIG. **1.**

FIG. **3** is a sectional view taken on the line B—B of FIG. **1.**

FIG. **4** is a partly cut-away side elevation of a modification of the cooling apparatus according to the present invention.

FIG. **5** is a partly cut-away front elevation of another modification of the cooling apparatus according to the present invention.

FIG. **6** is a sectional view taken on the line A—A of FIG. **5.**

FIG. **7** is a partly enlarged sectional view of the cooling apparatus.

FIG. **8** is a sectional view of a cooling tank.

FIG. **9** is a partly cut-away side elevation of a further modification of cooling apparatus according to the present invention.

The preferred embodiment of the present invention is shown in FIGS. **1–3.** In this mechanism, the radiation heat energy which has been radiated from the substances to be treated is first caught by the steel casing **11,** and the heat is then transferred to a low temperature fluid via the said casing. The steel casing **11,** which is located in the radiation heat transfer zone *b'*, is a box-shaped steel casing to which the low temperature fluid is fed. Other aspects of this mechanism will be better understood after an explanation of corresponding aspects of the FIGS. **5–8** embodiment.

After it has passed through the radiation heat transfer zone b', the temperature of the low temperature fluid which has passed through the radiation heat transfer zone (b') is somewhat elevated and then the said fluid is fed into the nozzles of the jet zone (a'). Thereafter, the fluid is jetted out into the apparatus as high-speed jet streams so as to cool the substances to be treated.

In another modification of the present cooling apparatus shown in FIG. **4**, the two jet zones a' are separated from each other, wherein the pressure of the high temperature air which has been released from a first jet zone a' is elevated by means of a fan **12** and then the said air is fed into a second jet zone (a') in which jet nozzles are provided, or in other words the said air is jetted into the apparatus from the said nozzles as high-speed jet streams. In this modification, the heat transfer efficiency may extremely be improved.

Other conveyer mechanism and walking beam mechanisms in the present cooling apparatus are the same as those of widely known reheating furnaces.

As explained in the above, by the use of the present apparatus the heat energy contained in heated steel ingots or blooms which has hitherto been left out in the iron works may efficiently be recovered. In addition, the present invention may be utilized for any and every apparatus for cooling substances by the use of high-speed jet streams.

In the next place, still another modification of the present cooling apparatus, which consists of a high-speed jet chamber, a cooling tank and a carriage, will be explained in the following, referring to the corresponding FIG. **5**, FIG. **6**, FIG. **7** and FIG. **8**.

High-speed jet chamber

In this jet chamber, a number of jet nozzles are provided at the upper side wall and the lower side wall with a determined distance from the substances to be treated, the central axis of each of which nozzles is kept in a vertical direction to the said substances, and a low temperature fluid is jetted into the chamber through the jet nozzles under high speed, whereby heat transfer is efficiently carried out between the low temperature fluid and the high temperature substances to be treated. This heat transfer utilizes the high coefficient of heat transfer on the surface of the substances caused by the use of the low temperature jet fluid, which is a principle mechanism of the rapid cooling attained in this jet chamber. In this case, the heat energy contained in the substances to be treated is transferred to the jet stream fluid, and thus the said fluid thus heated may be utilized as a heat source in a boiler or in other various industrial furnaces, etc. for example, as a high temperature air for combustion.

Referring to FIG. **5** and FIG. **6**, which show the construction of the high-speed jet chamber of the present invention, the substances **1** to be treated are put on fixed beams **4** which are successively conveyed in the apparatus by the upper and lower movement and the front and rear movement of walking beams **3**. That is, the substances (**1**) are conveyed by the rectangular movement of the same, via wheels **8** put on inclined rails **7**. Posts **2** of the walking beams **3** are connected with a driving beam in a lower portion of the apparatus, piercing through a lower portion of a casing **10**. In the piercing portion, gas seal boxes **6** and seal plates **18** are provided so as to prevent a gas leakage in the apparatus. Each of the posts **2** and the walking beams **3** is covered with heat shielding plates **5**, since both the posts **2** and the beams **3** are exposed to radiation from the high temperature substances and are exposed to a high temperature fluid. Alternatively, air cooling or water cooling pipes may be used therefor. On the beams **4** and **3**, casting rails **3'** are located on both the fixed beam side and the walking beam side so as to prevent oxidation erosion.

The jet chamber consists of, as shown in FIG. **5**, a two-stage box-shape steel casing, made of a steel plate. A low temperature fluid which has been forwarded under pressure from a blower is fed into the interior part of the casing box (b), while the radiation energy radiated from the high temperature substances **1** is caught by the casing **11**, and thereafter the said energy is transferred to the introduced low temperature fluid via the said casing **11**, which is a role of the interior box-shape steel casing (b).

The nozzles **9** are fixed to the exterior box-steel casing (a) in the form of a square arrangement or a zigzag arrangement or any other optional arrangement, and they are projected into the interior of the chamber, piercing the interior box-steel casing (b). The low temperature fluid which has passed through the interior box-steel casing (b) is somewhat heated and then is reversely introduced into the exterior box-steel casing (a) at the outlet side for extraction and then fed into the respective nozzles **9**. Thereafter the said fluid is jetted out from the nozzles into the chamber under high speed, where it strikes against the surface of the substances to be treated, whereupon a heat transfer takes place between the fluid and the substances. After the heat transfer, the fluid is taken away through the outlet **13** provided at one end portion of the chamber.

In each of the feeding inlet and the extracting outlet of this high-speed jet chamber, a nozzle **17** is provided, and the fluid in the interior of the chamber is sealed by means of an air jet film gushing out from the said nozzle **17**. The substances to be treated are fed to the front of the chamber by means of a rollgang **15** and then are conveyed into the interior thereof by means of the walking beams **3**. In addition, a pusher may also be used for the said feeding and conveying means.

Conveying apparatus

This apparatus consists of a pendent L-shape hook **19** which supports the substance **1** and which may move up and down and a carriage **20** which carries the hook **19** back and forth. The substance **1** which has been extracted from the high-speed jet chamber is carried to the upper position of a cooling tank **21** in the next step by means of the L-shape hook **19** of this apparatus, and then the hook is brought down together with the substance **1** at that position at last to sink wholly the substance **1** into water of the cooling tank **21**. The substance **1** is thereafter cooled nearly to normal temperature in the said cooling tank **21** for a determined period of time, and then in lifted up again and is carried by means of the carriage **20** to a conveying roller **22** in the final step. The carriage **20** is put on a carriage supporting beam **23** via wheels **24**, which beam **23** is connected directly to the jet chamber. The back and forth movement of the carriage **20** is accomplished by means of a carriage driving device **25** which is located on the said carriage **20**. The hook **19** which is hung on the carriage **20** is moved up and down by means of a driving device which also is located on the said carriage **20**.

Cooling tank

The substances which have been extracted from the high-speed jet chamber have at the time of being extracted a temperature of at most about **450°–500°C**, and thus it is necessary to further cool the said substances nearly to normal temperature rapidly and in a short period of time. In the present apparatus, therefore, the cooling tank **21** is parted into two parts by means of a partition wall **28** and the water in both of the upper side and the lower side water rooms **26** and **27** is circulated by means of a circulation pump **30** whereby a high flowing speed may be imparted to the water in the tank, for the purpose of the above said rapid cooling of the substance **1**, or more precisely for the purpose of increasing the coefficient of heat transfer between the substance **1** sunk into water and the water in the tank, whereby the substances may be cooled rapidly.

Referring to FIG. **8**, the substance **1** which is supported by the L-shape hook **19** is placed in the upper side water room **26** wherein the water is circulated by means of the circulation pump to make a high-speed water flow therein. By virtue of the said high-speed water flow, a high coefficient of turbulent flow heat transfer is conducted between the surface of the said substance and the said water flow, and thus the heat energy of the substance is efficiently transferred to the water flow whereby the said substance is rapidly cooled nearly to normal temperature. Incidentally, in order to remove with ease the scales, etc. in the cooling tank **21**, the lower portion of the casing of the upper and the lower water rooms **26** and **27** of the cooling tank **21** is inclined and a scale hopper **29** is provided at one end of the inclined casing wherein the scales are collected. The scales collected in the hopper may be removed periodically.

As explained in the above, substances having high temperature may be cooled continuously and for a short period of time, according to the present invention, and further, the whole apparatus for cooling may compactly be integrated. These are characteristic merits of the present invention.

In the present apparatus, the whole is compactly integrated and thus the necessary space therefor may be reduced much. Further, repairing of the defective parts on slabs, etc. may be performed immediately, and thus the operation efficiency may also improved. These are also merits of the present invention.

What is claimed is:

1. A cooling apparatus comprising in line, a radiation cooling chamber; a high-speed jet chamber in which substances to be treated, such as steel ingots or blooms, are subjected to contact with high-speed jet streams of a cold fluid gushing out from a large number of nozzles located therein, thereby carrying out a heat transfer between the substances and the cold fluid to cool the former, the substances being conveyed in the apparatus during the course of the cooling; a cooling tank in which the substances carried out from the said high-speed jet chamber are rapidly cooled nearly to normal temperature by increasing the flowing speed of water or a cold liquid in the tank; and a carriage which operates to convey the said substances from the said high-speed jet chamber into the said cooling tank.

2. A cooling apparatus for substances, such as steel ingots or blooms, to be cooled from high temperatures, said apparatus comprising:

1. a radiation cooling chamber composed of cooling surfaces of steel;

2. a first high speed jet stream chamber;

3. a plurality of nozzles located in said first high speed jet stream chamber and adapted to jet at a high speed a low temperature fluid on a substance located in said first high speed jet stream chamber;

4. first means for moving a substance to be cooled through said radiation cooling chamber, to said first high speed jet stream chamber, and through said first high speed jet stream chamber;

5. second means for providing and jetting through said plurality of nozzles at a high speed a low temperature fluid;

6. a cooling tank; and

7. third means for moving a substance to be cooled from said first high speed jet chamber to said cooling tank,

whereby a substance to be cooled can first be gradually cooled in said radiation cooling chamber and then be quickly further cooled in said first high speed jet stream chamber and said cooling tank.

3. A cooling apparatus as claimed in claim **2** and further comprising means for providing an air curtain at the inlet of said radiation cooling chamber and at the outlet of said first high speed jet stream chamber.

4. A cooling apparatus as claimed in claim **2** wherein said first means is a pusher means.

5. A cooling apparatus as claimed in claim **2** wherein said first means is a walking beam device.

6. A cooling apparatus as claimed in claim **2** wherein said first means is of the chain type.

7. A cooling apparatus as claimed in claim **2** and further comprising a water sealing device for sealing furnace from outside located at the furnace floor penetrating portion of the carrying mechanism.

8. A cooling apparatus as claimed in claim **2** wherein said third means comprises an L-hook suspended from a truck driving device.

9. A cooling apparatus as claimed in claim **2** and further comprising means for causing a low temperature fluid in said cooling tank to circulate therein at a high speed.

10. A cooling apparatus as claimed in claim **2** and further comprising a scale hopper and means located in said cooling tank for separating scales from a substance to be cooled.

11. A cooling apparatus as claimed in claim **2**

wherein said first means comprise walking beams for supporting substances to be cooled, posts supporting said walking beams and extending through apertures in the floor of said first high speed jet stream chamber, a system of inclined rails, and wheels rotatably mounted on the lower ends of said posts for contact with and guidance by said system of inclined rails and

further comprising a gas seal box mounted on each of said posts beneath said first high speed jet stream chamber and cooperating seal plates mounted on the floor of said first high speed jet stream chamber surrounding said apertures therein and extending downwardly into said gas seal boxes, whereby gas leakage from said first high speed jet stream chamber is prevented.

12. A cooling apparatus for substances, such as steel ingots or blooms, to be cooled from high temperatures, said apparatus comprising:

1. a first high speed jet stream chamber;
2. a first plurality of nozzles located in said first high speed jet stream chamber and adapted to jet at a high speed a low temperature fluid on a substance located in said first high speed jet stream chamber;
3. a second high speed jet stream chamber;
4. a second plurality of nozzles located in said second high speed jet stream chamber and adapted to jet at a high speed a low temperature fluid on a substance located in said second high speed jet stream chamber;
5. a duct connecting said first and second high speed jet stream chambers in series;
6. a fan contained in said duct;
7. first means for moving a substance to be cooled through said first high speed jet stream chamber, to said second high speed jet stream chamber, and through said second high speed jet stream chamber;
8. second means for providing and jetting through said first plurality of nozzles at a high speed a low temperature fluid; and
9. third means for providing and jetting through said second plurality of nozzles at a high speed a low temperature fluid.

13. A cooling apparatus as claimed in claim 12 and further comprising means for providing an air curtain at the inlet and outlets of said first and second high speed jet stream chambers.

14. A cooling apparatus as claimed in claim 12 wherein said first means comprise walking beams for supporting substances to be cooled, posts supporting said walking beams and extending through apertures in the floor of said first high speed jet stream chamber, a system of inclined rails, and wheels rotatably mounted on the lower ends of said posts for contact with and guidance by said system of inclined rails and

further comprising a gas seal box mounted on each of said posts beneath said first high speed jet stream chamber and cooperating seal plates mounted on the floor of said first high speed jet stream chamber surrounding said apertures therein and extending downwardly into said gas seal boxes, whereby gas leakage from said first high speed jet stream chamber is prevented.

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